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Intelligent Borewell Safety System Using Proximity Sensors and Automated Closure Mechanism

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Abstract: Borewells serve as essential water sources but become potential hazards when left uncovered, and manual supervision, lack reliability and real-time intervention, making them ineffective in preventing such incidents. To address these shortcomings, an Automated Borewell Safety System is designed to detect movement near an uncovered borewell and trigger preventive actions. Ultrasonic Sensors and Infrared (IR) Sensors continuously monitor a 1-foot radius around the borewell. Upon detection of movement, a buzzer and colorful LEDs are activated to provide an immediate visual and audible warning. A display unit offers real-time status updates, while an ESP8266 Wi-Fi module transmits alerts to the concerned authorities for prompt action. To enhance safety further, a servo motor-driven cover mechanism is programmed to automatically close the borewell with a slight delay, ensuring any detected object has time to move away before the closure. This system integrates real time monitoring, instant alerts, and automated preventive mechanisms to provide an efficient, cost-effective, and scalable solution, significantly reducing the risk of accidents caused by uncovered borewells and drainage pits.

Keywords- Borewell Safety, IoT-Based Monitoring, Real-Time Hazard Detection, Ultrasonic and IR Sensors, Automated Cover Mechanism, ESP8266 Wi-Fi Module

1. INTRODUCTION

Borewells play a vital role in ensuring access to groundwater, especially in regions where municipal water supply is inadequate or unavailable. In many parts of India and other developing countries, borewells serve as primary sources of water for both domestic and agricultural use. However, despite their utility, borewells have also emerged as significant safety hazards, especially when they are left uncovered, abandoned, or poorly maintained. Over the years, numerous tragic incidents involving children and animals falling into uncovered borewells have been reported, highlighting a critical gap in safety and monitoring infrastructure. These accidents are often fatal due to the narrow structure of borewells and the difficulties involved in executing timely rescues.

Traditional borewell safety measures primarily depend on manual monitoring, physical barricading, or temporary coverings using wooden planks or metal sheets. These approaches are unreliable and vulnerable to wear, environmental damage, and human negligence. Additionally, manual supervision lacks the real-time responsiveness required to prevent accidents, making it insufficient for ensuring consistent safety. The need for an intelligent, automated solution that can actively detect potential threats and initiate preventive measures is therefore imperative.

This paper presents an IoT-based Automated Borewell Safety System designed to detect movement near uncovered borewells and trigger a series of preventive actions. The system is engineered to combine real-time monitoring, instant alerts, and a mechanical intervention mechanism in a cost-effective and scalable design. Central to the system's functionality are ultrasonic and infrared (IR) sensors positioned strategically around the borewell to detect any movement or proximity within a one-foot radius. These sensors serve as the first line of defense by continuously scanning the surrounding area for unusual activity.

Upon detecting any motion—whether it be a child, animal, or object—the system immediately activates a set of visual and auditory alerts. A buzzer sounds to draw attention, while a series of colorful LEDs light up to provide a visual cue of danger. These signals serve both as a warning to nearby individuals and as an alert for local responders. Simultaneously, the system's ESP8266 Wi-Fi module transmits real-time alerts to concerned authorities, family members, or emergency services via cloud-based platforms or messaging systems. This ensures that necessary action can be taken without delay.

A unique feature of the system is its servo motor-driven automatic cover mechanism. After a brief programmed delay, which allows any detected object or person time to move away, the cover closes over the borewell. This mechanical response helps prevent accidents in scenarios where the visual and sound warnings are not sufficient. The delay mechanism is critical in ensuring the safety of nearby individuals while maintaining the responsiveness of the system.

The proposed system stands out for its practical advantages: it is low-cost, easy to deploy, and scalable for wider implementation. Unlike complex rescue operations that often cost significant resources and may not always succeed, this solution offers a preventive approach that can reduce the occurrence of such incidents altogether. Moreover, it can be adapted for use in other high-risk environments, such as drainage pits, manholes, and construction sites. By integrating Internet of Things (IoT) technology with simple yet effective mechanical components, this system aligns with the growing trend of smart public safety infrastructure. It demonstrates how affordable and accessible electronics can be harnessed to solve real-world problems and protect vulnerable populations, especially children, in rural and semi-urban communities.

2. LITERATURE SURVEY

1. Surya Saravana Pandian and Karthikeyan Sundarsamy (2018) – "Multi-Purpose Prosthetic Borewell Rescue Robot System"

This paper introduces a multi-functional rescue robot designed to address the challenges associated with retrieving victims from borewells. The proposed system integrates prosthetic limbs with robotic mechanisms to enhance the robot's ability to navigate the confined and often hazardous environment of a borewell. The robot is equipped with sensors to detect obstacles and assess the condition of the victim, allowing for precise and safe retrieval operations. Additionally, the system features a communication module to relay real-time data to rescue teams, facilitating coordinated efforts during emergencies. The design emphasizes modularity and adaptability, enabling the robot to be customized for various rescue scenarios beyond borewells.

2. K. Kanisha (2018) – "Design and Development of Robot for Rescue Operations for Borewell Victims"

In this study, the author presents the design and development of a robotic system aimed at rescuing individuals trapped in borewells. The robot is designed to descend into the borewell and reach the victim using a combination of wheels and tracks, ensuring stability and maneuverability in the narrow shaft. Equipped with a gripper arm, the robot can securely grasp and lift the victim, bringing them to safety. The system is controlled remotely, allowing operators to manage the rescue operation from a safe distance. The paper discusses the technical challenges encountered during development, including power supply constraints and communication issues, and the solutions implemented to overcome these obstacles.

3. Yong-Jin Liu et al. (2017) – "Real-Time Movie-Induced Discrete Emotion Recognition from EEG Signals"

This research focuses on developing a real-time system for recognizing discrete emotions induced by movie clips using electroencephalography (EEG) signals. The study involved 30 participants who watched 16 standardized film clips designed to evoke specific emotions. EEG data was collected during the viewing sessions and analyzed to identify patterns associated with different emotional states. The system achieved an overall accuracy of 92.26% in recognizing high-arousal and valenced emotions from neutrality, and 86.63% in

distinguishing positive from negative emotions. The findings highlight the potential of EEG-based emotion recognition systems in applications such as human-computer interaction and affective computing.Yong-Jin Liu+1ResearchGate+1

4. S. Sathishkumar et al. (2017) – "Design and Development of a Robotic System for Rescue of Children Trapped in Borewells"

This paper presents the design and development of a robotic system specifically tailored for rescuing children trapped in borewells. The robot is designed to navigate the narrow and often challenging environment of a borewell, employing a combination of wheels and tracks for movement. Equipped with a gripper arm, the robot can securely grasp and lift the child, bringing them to safety. The system is controlled remotely, allowing operators to manage the rescue operation from a safe distance. The paper discusses the technical challenges encountered during development, including power supply constraints and communication issues, and the solutions implemented to overcome these obstacles.

5. G. Kavianand et al. (2016) – "Smart Child Rescue System from Borewell (SCRS)"

This research introduces the Smart Child Rescue System (SCRS), a robotic system designed to rescue children trapped in borewells. The system utilizes a combination of sensors and actuators to navigate the borewell and reach the trapped child. Once in proximity, the robot employs a gripper arm to securely grasp the child and lift them to safety. The system is controlled remotely, allowing operators to manage the rescue operation from a safe distance. The paper discusses the design considerations, including the selection of materials and components to ensure the robot's functionality and safety during operations.

6. S. Simon et al. (2016) – "Borewell Rescue Robot"

This paper presents the design and development of a borewell rescue robot aimed at retrieving individuals trapped in borewells. The robot is designed to descend into the borewell and reach the victim using a combination of wheels and tracks, ensuring stability and maneuverability in the narrow shaft. Equipped with a gripper arm, the robot can securely grasp and lift the victim, bringing them to safety. The system is controlled remotely, allowing operators to manage the rescue operation from a safe distance. The paper discusses the technical challenges encountered during development, including power supply constraints and communication issues, and the solutions implemented to overcome these obstacles.

3. PROPOSED SYSTEM

The Intelligent Borewell Safety System is designed with an emphasis on automation, safety, and real-time monitoring. This IoT-based system integrates a set of environmental sensors, actuators, and communication modules to identify potential threats near uncovered or unattended borewells and respond autonomously to prevent accidents. The design utilizes a modular approach that ensures reliability, efficiency, and scalability for deployment in both urban and rural environments.

Borewell Web Application

The Borewell Web Application serves as the primary interface for monitoring and managing the safety system remotely. It is designed to provide real-time information on the borewell's status, including sensor data, alerts, and actions taken by the system. End users, such as local authorities, maintenance teams, and safety personnel, can access this web-based platform to receive alerts and view detailed logs of the system’s performance. The application supports notifications and displays a dashboard with essential system information, allowing quick responses to potential safety issues around the borewell

The diagram of the Automated Borewell System is designed using a modular and layered approach that integrates both hardware and software components to ensure efficient water management, system reliability, and real-time monitoring. At the core of the architecture is the Arduino Uno microcontroller, which functions as the

central processing unit. It handles logic execution, data acquisition, and communication between connected sensors and actuators to automate the water pumping process. The hardware system includes several key modules interfaced with the Arduino Uno.

An Ultrasonic Sensor is used to monitor the water level within the borewell shaft. This sensor continuously sends distance data to the Arduino, enabling the system to determine whether the water level is sufficient for pumping. This prevents dry-run conditions that could damage the pump and waste energy. Upon verifying that there is enough water, the Arduino activates a relay module that switches on the submersible water pump. The pump draws water from the borewell and transfers it to an overhead tank or a storage facility. The automated control of the pump not only ensures optimal operation but also reduces human intervention and operational inefficiencies.

Real-time status updates are provided through an LCD Display, which shows information such as the current water level, pump status (ON/OFF), and potential warnings like low water or pump fault. This user-friendly feedback enhances monitoring and is particularly helpful in rural areas where technical expertise may be limited. To enhance remote control and monitoring, the system integrates a GSM Module, which can send SMS alerts to the user's mobile phone. These alerts may include information such as pump activation, water level status, or any system malfunctions. This feature ensures that users are always informed, even if they are not physically present at the site.

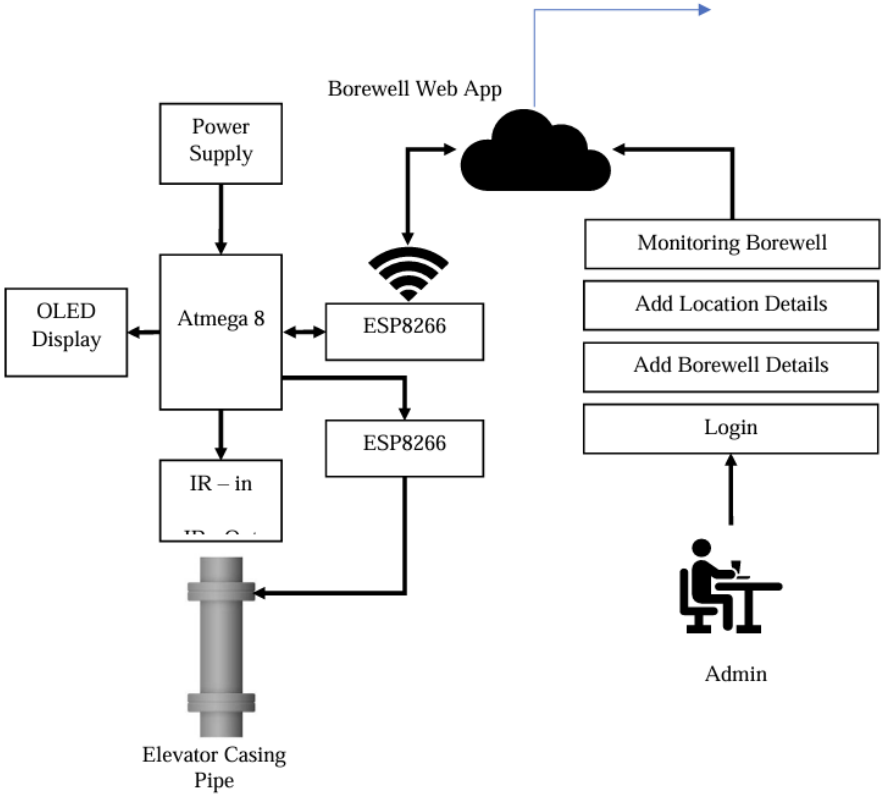

FIGURE 1. Three-Tier Web Application Architecture.

4. CONCLUSION

In conclusion, open and unmonitored borewells have emerged as a serious threat to public safety, especially for children and animals in rural and urban areas. Traditional safety measures often fall short due to their lack of automation and real-time responsiveness. This paper presents an intelligent, IoT-enabled borewell safety system designed to prevent such life-threatening incidents by integrating

real-time proximity detection and automated closure mechanisms. Using a combination of ultrasonic and infrared sensors, the system can effectively monitor any movement around the borewell and trigger immediate alerts through buzzers, LEDs, and Wi-Fi-based notifications to concerned authorities. The servo motor-driven lid ensures timely physical closure of the borewell, thereby eliminating access risks. The system is powered by a microcontroller and supported by a responsive web application, allowing authorities and residents to monitor borewell safety remotely. By automating detection, alert, and response processes, this project significantly reduces the likelihood of accidents and enhances public safety. In the future, this system can be further upgraded with AI-based predictive analytics and solar-powered components to make it more sustainable, autonomous, and adaptable to various terrains and weather conditions.

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